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Module Introduction

Overview

Electrostatic discharge (ESD) is a major cause of damage to integrated circuits (ICs) and circuit boards. What causes ESD? How serious is this damage? What can you do to avoid it?

What You Will Learn

By the end of this module, you will:

- Know what you should do to prevent ESD damage
- Be able to set up an ESD-safe workstation
- Use equipment and materials designed to prevent ESD damage

The “Skills Checklist” following this Module Introduction lists in detail the tasks you will learn in this module.

How You Will Be Tested

Module Test - This written test will help you check your understanding of the material presented in the module.

Prerequisite Exam - This test, consisting of written and hands-on parts, will verify that you understand the risks of ESD and know the ESD prevention rules.

In the Lab part of this course - Throughout the hands-on exercises, the Course Manager will observe your behavior to verify that you follow all ESD prevention rules.
To pass this course, you must exhibit ESD-safe behavior.

Prerequisites to the Module

Before you begin this module, you must have completed the “Welcome to Apple Service” module.

Materials Provided for this Module

The Prerequisite provides the following items for this module:

- This Module Workbook
- Videotape entitled *The Shocking Truth*
- Module Test

Module Introduction

Materials You Need to Provide

Completing this module requires that you set up an ESD-safe workstation. For that exercise, you will need to provide the following materials:

- a conductive workbench mat with ground cord
- a wriststrap, with a built-in 1-megohm resistor and ground cord
- an equipment ground cord, with alligator clips
- a ground/polarity tester

If you don't already have these materials, you can buy them at most electronics shops.

How this Module Is Organized

This module is presented in two parts:

Part 1 - ESD Prevention - The videotape "The Shocking Truth" explains what ESD is, how it causes damage, and what can be done to prevent the damage. The prevention rules are further explained in this module.

Part 2 - An ESD-Safe Work Area - This part explains the equipment that you should use to prevent ESD damage, and provide directions for setting up and using an ESD-safe workstation.

Following these two parts is a Module Summary.

Continue with the Skills Checklist on the following pages.

Skills Checklist

What Is the Skills Checklist?

This is a list of tasks that you should be able to perform at the conclusion of this module. The Prerequisite Exam will cover these items. During the Lab part of this course, you will be expected to be able to perform all of these tasks.

How to Use the Checklist

Before starting the module, you should check the items on this list to see which tasks you can already perform. If you are confident that you can already perform certain tasks, you may decide to skip those parts of the module. Or you may decide to try the Module Test without going through the module.

After completing the module, you should check this list to make certain that you have mastered all the skills before you attend the Prerequisite Exam and Lab part of this course. If you feel uncertain about any of these tasks, you should return to the section indicated, review the information and repeat the hands-on exercises.

Skills Checklist

Task	Section Where the Task is Covered
____ 1. Explain in general terms what ESD is and how it causes damage.	<i>The Shocking Truth</i> videotape
____ 2. State the seven ESD prevention rules.	Preventing ESD
____ 3. Describe ways that you can inform other people about the risks of ESD.	Preventing ESD
____ 4. List the minimal equipment that you must use at your workstation to reduce the ESD risk.	<i>The Shocking Truth</i> videotape Equipment for Preventing ESD
____ 5. Explain (in general terms) what each piece of ESD preventative equipment does to reduce the ESD risk.	<i>The Shocking Truth</i> videotape Equipment for Preventing ESD
____ 6. Remove all ESD hazards from your work area.	<i>The Shocking Truth</i> videotape Setting Up an ESD-Safe Workstation
____ 7. Set up a conductive workbench mat.	<i>The Shocking Truth</i> videotape Setting Up an ESD-Safe Workstation
____ 8. Provide adequate grounding for your work area.	<i>The Shocking Truth</i> videotape Setting Up an ESD-Safe Workstation
____ 9. Put on a wrist strap properly and wear it at appropriate times.	<i>The Shocking Truth</i> videotape Setting Up an ESD-Safe Workstation
____ 10. Explain ESD preventative steps to be taken when working at a customer's site.	<i>The Shocking Truth</i> videotape Setting Up an ESD-Safe Workstation

Continue with the next section - Preventing ESD.

Preventing ESD

View the videotape "The Shocking Truth." Then, continue with this section.

The Shocking Truth

The videotape "The Shocking Truth" explained what ESD (electrostatic discharge) is, why it is a serious problem, and what you can do to reduce ESD damage. The rest of this section presents basic rules for preventing ESD damage and suggests ways to inform other people about the dangers of ESD.

ESD Prevention Rules

You are expected to learn the following seven rules and to apply them whenever you work on Apple equipment. To help you remember them, we have provided a key word for each rule.

Grounds

Before working on any device containing a printed circuit, ground yourself and your equipment to an earth or building ground.

Use a grounded conductive workbench mat and a grounding wrist strap, and ground your equipment to the mat.

Warning: *Do not ground yourself when working on "live" (plugged in) equipment or when discharging a Cathode Ray Tube (CRT).*

Bodies

Don't touch anybody who is working on integrated circuits.

If that person is properly grounded, your "zap" may not cause any damage, but just to be on the safe side, keep your own body charge away from other technicians.

Bags

Use static-shielding bags for boards and ICs during storage, transportation, and handling.

Before you leave your bench to take a board to a storage place, put the board in a static-shielding bag. Leave all Apple service exchange components in their ESD-safe packaging until needed.

Preventing ESD

Leads

Handle all ICs by the body, not by the leads.

Also, do not touch PCB edge connectors, exposed circuitry, or printed circuits. Handle ICs and PCBs by the edges, or use extractors.

Synthetics

Do not wear polyester clothing or bring plastic, vinyl, or styrofoam into the work environment.

The electrostatic field that surrounds these nonconductors cannot be totally removed.

Metals

Never place components on any metal surface.

Use antistatic or conductive mats or foam.

Atmosphere

If possible, keep the humidity in the service area between 70% and 90%, and use an ion generator.

Charge levels are reduced (but not eliminated) in high-humidity environments. Using an ion generator neutralizes the charge surrounding nonconductors. However, this type of device can't provide total protection because the static charges often cause ESD damage before the neutralizing process eliminates the charge.

Preventing ESD

Spreading the Word about ESD

Let's say that you always follow the ESD prevention rules but, as shown in the videotape, visitors to your work area still pose considerable risk to your equipment. What can you do to keep other people from unknowingly being an ESD hazard?

You need to educate them. As a technical expert at your site, you may be able to tactfully inform your fellow workers and customers about the dangers of ESD and its prevention.

Videotape

Share the videotape *The Shocking Truth* with other people at your site. It is an easy and entertaining way to educate your fellow workers.

Set an Example

Another way to encourage ESD-safe behavior in your workshop is to be certain that you set a good example by always following the ESD prevention rules. At times, you may find it appropriate to explain ESD prevention to others, for example, why you keep styrofoam away from the work area.

Remember - follow the ESD prevention rules **at all times**. It's the only safe way.

Continue with the next section - Exercise: Preventing ESD.

Exercise: Preventing ESD

Part 1

Indicate whether the following items are correct or incorrect by checking TRUE or FALSE.

1. A static discharge as little as 30 volts can damage some circuit boards.
☐ TRUE ☐ FALSE
2. You can feel a static discharge of 30 volts.
☐ TRUE ☐ FALSE
3. A charged nonconductor (for example, a styrofoam cup) can cause damage only if it touches the circuit board.
☐ TRUE ☐ FALSE
4. Testing circuit boards is a sure way of determining whether or not they have been damaged by ESD.
☐ TRUE ☐ FALSE
5. Usually you cannot see the damage caused by ESD.
☐ TRUE ☐ FALSE

Exercise: Preventing ESD

6. State two ways that you could "spread the word" about the risks of ESD and its prevention.

a. _____

b. _____

Compare your answers to those on the next page.

Exercise: Preventing ESD (Answers)

Part 1

Compare your answers to the statements below.

1. TRUE
2. FALSE. If you can feel the voltage, it is probably as high as 3,000. An ESD of as low as 30 volts can damage many modern-day circuit boards.
3. FALSE. The electro-static field surrounding the nonconductor can discharge voltage to the conductor and thus damage it—without the two objects touching.
4. FALSE. ESD often degrades the circuits in a way that the system will continue to function and thus pass the diagnostic tests, but at a later time, the unit may start to malfunction or have intermittent problems.
5. TRUE
6. Here are some things you could do to educate others about ESD:
 - a. Show the videotape to them.
 - b. Set an example by adhering to all ESD prevention rules.

**If you missed more than one of these items, view the videotape again.
Otherwise,**

Continue with the next part of this exercise.

Exercise: Preventing ESD

Part 2

Write the seven ESD Prevention Rules in your own words.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

Compare your answers to those on the next page.

Exercise: Preventing ESD (Answers)

Part 2

Compare your answers to the statements below.

1. Before working on any device containing a printed circuit, ground yourself and your equipment to an earth or building ground.
2. Do not touch anybody who is working on integrated circuits.
3. Use static-shielding bags for boards and chips during storage, transportation, and handling.
4. Handle all ICs by the body, not by the leads.
5. Do not wear polyester clothing or bring plastic, vinyl, or styrofoam into the work environment.
6. Never place components on any metal surface.
7. If possible, keep the humidity in the service area between 70% and 90%, and use an ion generator.

If you missed one or more of the items of this exercise, review the section "ESD Prevention Rules".

Otherwise....

Continue with the next section — Equipment for Preventing ESD.

Equipment for Preventing ESD

ESD Protective Equipment

The first step in creating an ESD-safe workstation is to acquire the materials and tools that can help you prevent ESD damage. What are these materials?

This section describes these basic materials and provides tips regarding their use. In the next section, you will learn how to set these materials up at your workstation.

Conductive Floor Mat

Using a conductive floor mat is one way to ground yourself. As soon as you step on the mat, you become grounded, and your body will not hold a static charge. If you use a floor mat, be sure that you step on the floor mat before reaching for your wrist strap or turning on an ion generator.

All visitors without wrist straps must also contact the floor mat before approaching the workstation.

Wrist Strap

Using a properly grounded wrist strap is another way to ground yourself. As long as you are wearing a grounded wrist strap your body cannot hold a static charge.

Always put your wrist strap on before beginning work. Every time you put it on, visually inspect it to be sure it is connected properly. Be sure that it touches skin and is on snugly. Taking your wrist strap off should be the last thing you do before leaving the work area.

A common myth is that you do not need wrist straps unless you work on carpeted floors. That is not true, there is considerable ESD risk on all types of floors. Unless you are grounded, you can't be sure that you are ESD-safe.

Do not wear a wrist strap when working with Cathode Ray Tubes (CRTs). CRTs carry high voltage that can be transferred to you through the wrist strap.

Conductive Workbench Mat

A conductive workbench mat provides a work surface that is static-safe and will not hold a static charge. When you place conductive items like PCBs on the conductive mat, their static charge is drained to ground. Static shielding bags, conductive tote boxes, conductive foams and conductive shipping tubes all lose their charge when placed on the mat.

Always lay conductive containers on the mat and attach your wrist strap before removing the components from the containers.

Equipment for Preventing ESD

Ground Cords

Use a ground cord to ground your workbench mat. Become familiar with where the ground cords are located. Visually inspect them each day to be sure they have not been accidentally disconnected.

Static-Shielding Bags

A particularly hazardous time for static-sensitive components is during handling and shipping. Static charge on objects and people, even static buildup resulting from the movement of the parts themselves, can destroy or degrade parts. Whenever you transport or store boards and chips, use static-shielding bags for protection against static discharge and external static fields.

Some bags are just anti-static which means they do not create static electricity, but they also do not shield their contents from external static fields. Be sure to use bags that are anti-static and static-shielding.

Be sure that the bags you use are new. Throw out bags that appear worn because they will not provide adequate protection.

Ion Generator

You cannot ground nonconductive materials, such as plastic and synthetic fabrics. An ion generator can help to neutralize their static charge.

If you use an ion generator, turn it on immediately after attaching your wrist strap.

What Equipment Is Required

You may not be able to acquire all the materials described above, but setting up an ESD-safe workstation requires at least the following:

- Conductive workbench mat with ground cord
- Wriststrap with 1 megohm resistor and ground cord
- Equipment ground cord with alligator clips
- Ground/polarity tester (to test grounding of power outlet)
- Static-shielding bags

You should be able to buy all of this equipment at electronics shops.

Continue with the next section — Setting Up an ESD-Safe Workstation.

Setting Up an ESD-Safe Workstation

Introduction

Before you start to work on any task involving circuit boards, you need to verify that your workstation is ESD safe. An ESD-safe workstation is one that has equipment and materials designed to prevent ESD damage.

This section will guide you through the steps to set up an ESD-free workstation. If you do not already have an ESD safe workstation set up, perform these steps now. If you already have an ESD safe workstation set up, just read these steps.

What You Will Need for this Exercise

To complete this exercise, you will need the following equipment:

- conductive workbench mat with ground cord
- wrist strap with 1-megohm resistor and ground cord
- equipment ground cord with alligator clips
- ground/polarity tester

If you do not have all the equipment required to set up an ESD-safe workstation, obtain it as soon as possible and then complete this exercise.

Note: *The following steps may vary, depending on the ESD mat and equipment you use. Consult the instructions that come with the ESD equipment for further details.*

Steps for Setting Up an ESD-Safe Station

To set up an ESD-safe workstation, follow these steps:

1. Remove all ESD hazards from your work area. That includes:
 - Anything made of styrofoam, for example, styrofoam coffee cups
 - Common plastics
 - Synthetic clothing
 - Vinyl

Setting Up an ESD-Safe Workstation

2. Use the ground/polarity tester to verify proper grounding of the power outlet.

Ground/polarity testers vary slightly in design, but all are very simple to use. Insert the three prongs of the tester into the three-prong outlet, as shown in Figure 1. Most testers display a discrete light pattern for each possible wiring configuration. You interpret the light display by referring to the code given on the tester.

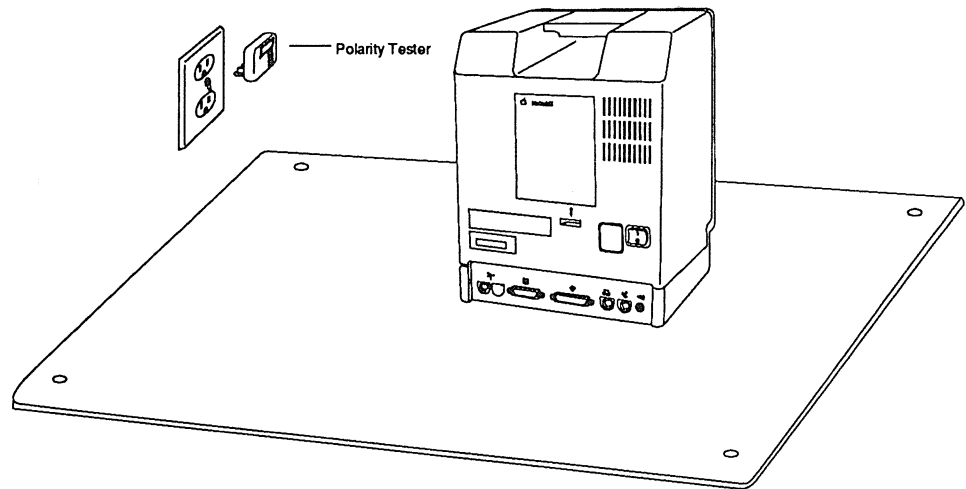


Figure 1. Using a ground/polarity tester

3. Lay out the conductive workbench mat. Use the ground cord to connect the mat to earth ground or to a building ground. Connecting the ground cord to the wall outlet box, as shown in Figure 2, is usually adequate, but to be certain about how to ground the mat, check with an electrician.

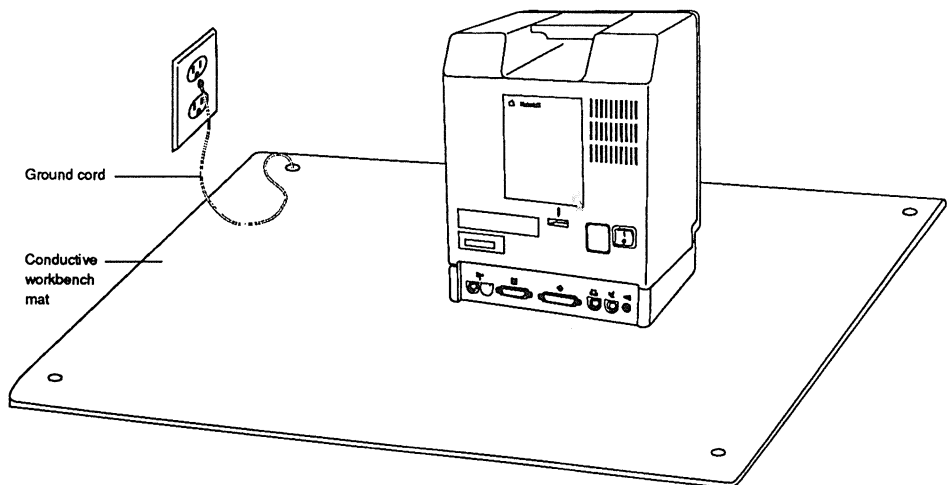


Figure 2. Grounding the workbench mat

Setting Up an ESD-Safe Workstation

4. Fasten the wrist strap ground cord to the workbench mat and connect the wrist strap, as shown in Figure 3. Put the wrist strap around your wrist so that the strap touches your skin.

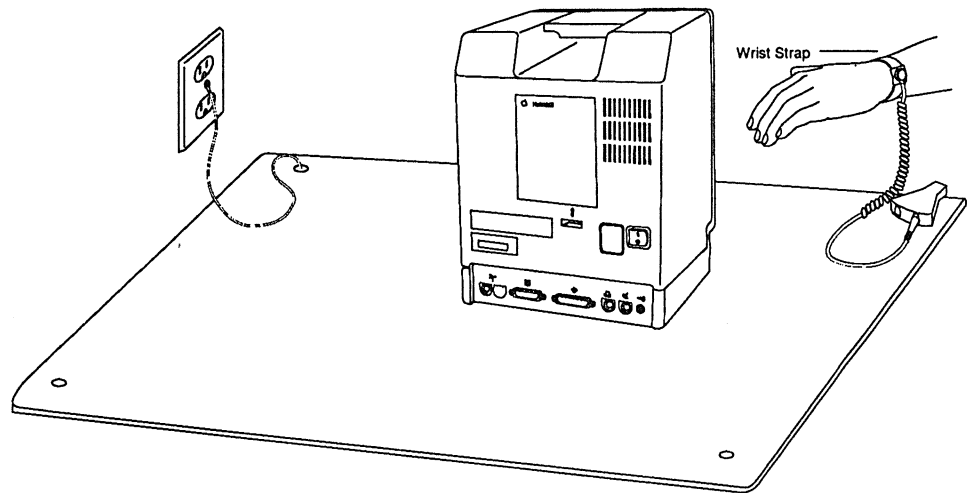


Figure 3. Grounding the wrist strap

5. Insert the power cord of the computer into the computer power socket. Do not plug the other end of the power cord into the wall outlet. Instead, use the ground cord with alligator clips to connect the ground pin (the long pin, sometimes called the "third wire") of the computer power cord to the workbench mat, as shown in Figure 4.

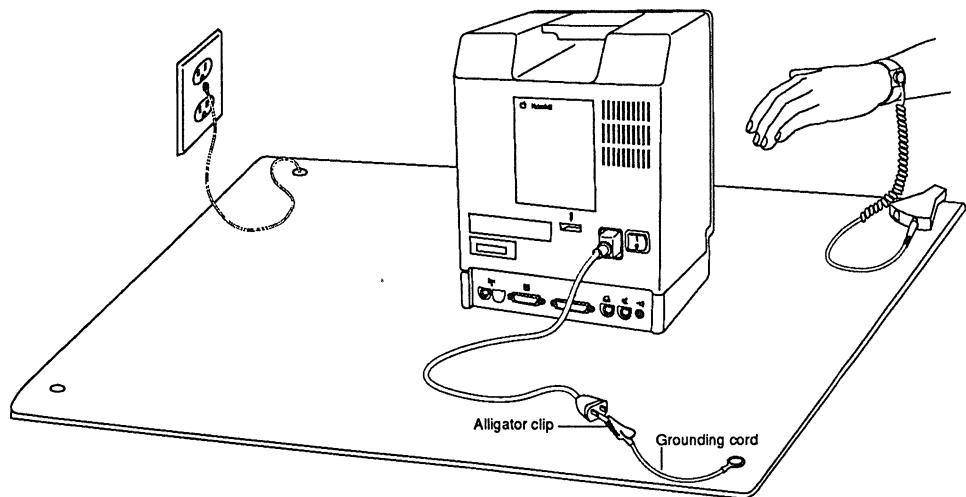


Figure 4. Grounding the Computer

Setting Up an ESD-Safe Workstation

In the Field

When you work at a customer site, you need to take the same precautions to avoid ESD damage. Take time to make the work area ESD safe. Use a workbench mat and wrist strap. (For travel convenience, you may want to use mats that fold up.) Be sure everything is properly grounded, and never set parts on the floor.

Continue with the next section - Module Summary.

Module Summary

The ESD Risk

Electrostatic discharge (ESD) is an industry-wide problem. Unless you take special precautions whenever you are working with circuit boards, ESD can destroy or damage the integrated circuits on the circuit boards.

Here are a few things to remember about ESD:

- A discharge as low as 30 volts can destroy a circuit board. You do not normally feel a static discharge until it approaches the 3,000-volt level.
- Nonconductors don't have to touch each other to result in ESD damage. The electrostatic field surrounding a nonconductor can discharge its voltage to another nonconductor without the two objects touching.
- Without special equipment, you normally cannot see the damage caused by ESD .
- Often ESD degrades ICs in a way that the unit continues to function properly, but over time malfunctions or develops intermittent problems.

Prevention Rules

These are the seven ESD prevention rules:

1. Before working on any device containing a printed circuit, ground yourself and your equipment to an earth or building ground.
2. Don't touch anybody who is working on integrated circuits.
3. Use static-shielding bags for boards and ICs during storage, transportation, and handling.
4. Handle all ICs by the body, not by the leads.
5. Do not wear polyester clothing or bring plastic, vinyl, or styrofoam into the work environment.
6. Never place components on any metal surface.
7. If possible, keep the humidity in the service area between 70% and 90%, and use an ion generator.

Module Summary

Spreading the Word About ESD

Educate your fellow employees and customers about the risks of ESD. Use the videotape "The Shocking Truth" provided with this module.

ESD Prevention Equipment

To prevent ESD damage, you must use at least these items at your workstation:

- conductive workbench mat
- wrist strap with 1 megohm resistor and ground cord
- ground/polarity tester
- static-shielding bags
- equipment ground cord with alligator clips

In addition, you can use a conductive floor mat and an ion generator.

ESD-Safe Workstation

By now, you should have equipped your workstation with the minimal ESD prevention equipment, and you should know how to use the equipment.

When you service units at a customer's site, remember to take all the same precautions to avoid ESD damage.

You have completed this module.

Check your skills and knowledge against the Skills Checklist.

Continue with the Module Test.

Module Test

For items 1 through 12, indicate whether the statements are correct or incorrect by checking TRUE or FALSE.

1. Static discharge must be at least 1000 volts before it can damage a circuit board.
☐ TRUE ☐ FALSE
2. If you do not feel the static discharge when you pick up a circuit board, you can be certain that you have not caused any ESD damage.
☐ TRUE ☐ FALSE
3. A charged nonconductor can damage a circuit board without actually touching it.
☐ TRUE ☐ FALSE
4. You should always test units after working on them because the tests will reveal any damage caused by ESD.
☐ TRUE ☐ FALSE
5. You can reduce the risk of ESD damage by grounding the nonconductors in your work area.
☐ TRUE ☐ FALSE
6. To be effective, a wriststrap must touch your skin.
☐ TRUE ☐ FALSE
7. You need to wear a wrist strap only if the floor in your work area is carpeted.
☐ TRUE ☐ FALSE

Module Test

8. You should not wear a wrist strap when you are working on live equipment.

___ TRUE ___ FALSE

9. An ion generator helps to neutralize the static charge of nonconductors.

___ TRUE ___ FALSE

10. You should frequently check ground cords to make sure they are connected.

___ TRUE ___ FALSE

11. When conductive materials are placed on a conductive workbench mat, the mat drains the static charge from the conductive materials.

___ TRUE ___ FALSE

12. You should use either anti-static bags or static-shielding bags to protect circuit boards from ESD damage.

___ TRUE ___ FALSE

Complete the remaining items by writing your answers.

13. Describe two ways that you can inform your fellow workers about the risks of ESD.

1) _____

2) _____

Module Test

14. What are the seven ESD prevention rules?

1) _____

2) _____

3) _____

4) _____

5) _____

6) _____

7) _____

Module Test

15. List the five pieces of equipment or materials that you must have to help you prevent ESD.

1) _____

2) _____

3) _____

4) _____

5) _____

Compare your answers to those on the following pages.

Module Test (Answers)

Compare your answers to the following.

1. FALSE - A charge as low as 30 volts can damage some circuit boards.
2. FALSE - If you feel static discharge, the voltage is probably as high as 3,000 volts.
3. TRUE - The voltage from the electrostatic field surrounding a nonconductor can discharge to a circuit board without actual contact.
4. FALSE - The first part of this statement is true—you should test units after servicing them. The second part of the statement is false—tests do not always reveal ESD damage. ESD often degrades the circuits in a way that the system will continue to work until a later time when the unit will start malfunctioning or have intermittent problems.
5. FALSE - You ground conductors; you cannot ground nonconductors. You can try to neutralize the charge surrounding nonconductors by using an ion generator.
6. TRUE
7. FALSE - Walking on any type of floor can build up a considerable electrical charge.
8. TRUE - You must not wear a wrist strap when working on live equipment because the wrist strap will conduct the voltage from the live unit through your body. Wear the wrist strap only when working with equipment that is not plugged in.
9. TRUE
10. TRUE
11. TRUE
12. FALSE - You should use bags that are both anti-static and shielding. Some bags are just anti-static, which means they do not create static electricity, but they do not shield their contents from external static.

Module Test (Answers)

13. Two ways that you can inform your fellow workers about the risks of ESD:

- 1) Show them the videotape *The Shocking Truth*.
- 2) Set the example by following all ESD rules

14. These are the seven ESD prevention rules:

- 1) Before working on any device containing a printed circuit, ground yourself and your equipment to an earth or building ground.
- 2) Don't touch anybody who is working on integrated circuits.
- 3) Use static-shielding bags for boards and chips during storage, transportation, and handling.
- 4) Handle all ICs by the body, not by the leads.
- 5) Do not wear polyester clothing or bring plastic, vinyl, or styrofoam into the work environment.
- 6) Never place components on any metal surface.
- 7) If possible, keep the humidity in the service area between 70% and 90%, and use an ion generator.

15. These are the five pieces of equipment and materials that you must have to help you prevent ESD.

- 1) a conductive workbench mat
- 2) a wrist strap, with 1 megohm resistor and ground cord
- 3) equipment ground cord, with alligator clips
- 4) ground/polarity tester
- 5) static-shielding bags

Reminder: *This written test does not verify that you can perform the hands-on tasks covered in this module. Be sure you can perform all of the tasks on the Skills Checklist.*

Before continuing with the next module, refer to the evaluation booklet and complete the evaluation for this module.